

The influence of traps on the steady state corrosion current in aluminium oxide

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The steady state corrosion current for homogeneous corrosion in aluminium / aluminium oxide / electrolyte systems is known to depend on several parameters as temperature, pH and composition of the electrolyte. The direct measurement of the corrosion current provides only information on the overall process and its dependence on the corrosion conditions. Further investigations on this system are generally difficult since most methods need a significant deviation from the equilibrium conditions. Assuming the validity of the Cabrera Mott model a thermally activated hopping mechanism is necessary for the ionic transport in the oxide. For a precise determination of the activation energy and a separation from concurrent processes such as dielectric relaxation and electronic tunneling an investigation in a wide temperature range is mandatory. To overcome the temperature limitations of wet electrochemistry MIM-systems (metal / insulator / metal-systems) with anodic oxide films from steady-state corrosion conditions were investigated.

Aluminium samples were drawn from the electrolyte under steady state corrosion conditions with potential control and covered with an evaporated silver layer [1]. The samples were mounted in an UHV chamber and current transients after voltage steps were recorded in the temperature range from 42 K to 420 K (see fig. 1). In the first few microseconds the current transient is dominated by the charging of the capacity. From 10 microseconds to 10 milliseconds the current decreases with a nearly -1 slope in the double logarithmic plot. Finally the time independent tunnel current sets in. Figure 1 shows that only the first one is almost independent on the temperature.

Figure 2 shows characteristic currents in the relaxation domain ( $t = 1\text{ ms}$  taken from figure 1) and in the tunnel domain ( $t = 1\text{ s}$ ) as a function of the temperature. The temperature dependence of the relaxation currents can be explained by a thermally activated emission of electrons from the trap states to the conduction band. By applying a model originally suggested by Simmons and Taylor [2] trap state distributions are derived, which explain the temperature dependence of the tunnel current. The trap state distribution is a result of the steady state corrosion condition.

This result is discussed in terms of charge transport through thin aluminium oxide films and allows a precise prediction of the breakdown stability.

References

[1] D. Diesing, A. W. Hassel, M. M. Lohrengel, *Thin Solid Films* **342** (1999) 282  
[2] J.G. Simmons, G.W. Taylor, *Phys. Rev. B.* **5** (1972) 553

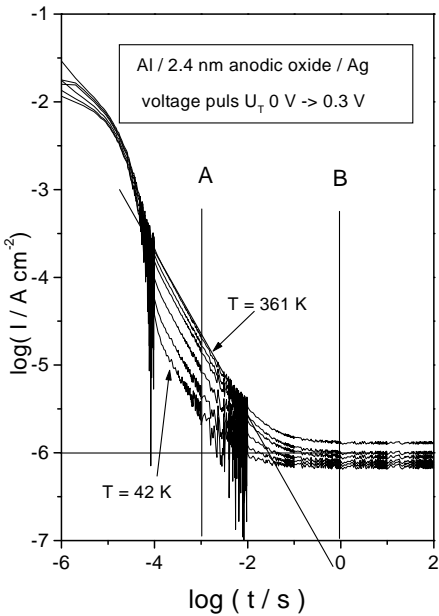


Fig. 1: Current transient after a voltage step from 0 V to 0.3 V of an aluminium / aluminium oxide / silver system at temperatures between 361 K, 289 K, 200 K, 148 K, 77 K and 42 K.

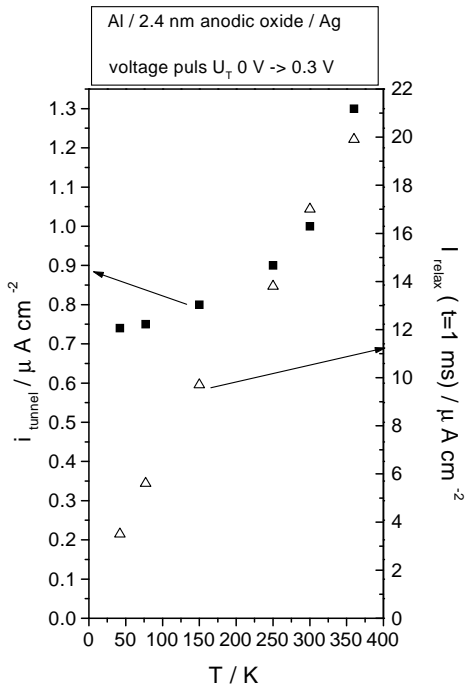


Fig. 2: Characteristic currents as a function of the temperature (taken from fig. 1).